

What is claimed is:

1. A computer readable medium having computer-executable instructions for performing a method for solving a traveling salesman problem, the method comprising:
  - 5 selecting a set of locations to visit;
  - selecting a starting point and an ending point from the set of locations;
  - applying a search method to the set of locations, the search including a genetic algorithm, the genetic algorithm including an objective function to simultaneously minimize distance and time; and
  - 10 providing a route as a solution to the traveling salesman problem, the route being from the starting point to the ending point, and visiting all locations in the set of locations, wherein the objective function evaluated the route to a value that is lower than any other path searched.
- 15 2. The computer readable medium as recited in claim 1, wherein the genetic algorithm generates populations of size  $2^k$ , where the set of locations is of size  $k$ .
3. The computer readable medium as recited in claim 2, wherein the genetic algorithm comprises: a selection operation, a crossover operation, and a mutation operation.
  - 20
4. The computer readable medium as recited in claim 3, wherein the genetic algorithm further comprises: encoding locations into chromosomes, the chromosome having the same number of positions as  $k$ , the locations being represented in each position by an integer.
  - 25
5. The computer readable medium as recited in claim 4, wherein the selection operation is CHC selection.
- 30 6. The computer readable medium as recited in claim 4, wherein the mutation operation comprises swapping two locations at two random positions in a chromosome.

7. The computer readable medium as recited in claim 4, wherein the crossover operation has a crossover probability between about 0.6 and 0.9.

5 8. The computer readable medium as recited in claim 4, wherein the mutation operation has a mutation probability between about 0.001 and 0.01.

9. The computer readable medium as recited in claim 4, wherein the crossover operation is greedy crossover.

10

10. A computer readable medium having computer-executable instructions for performing a method for finding a route in a supply chain, the method comprising:  
accessing a set of orders;  
selecting a set of supplier locations to visit to pick up products to fill the set of  
15 orders;  
searching for pickup paths visiting each supplier location in the set of supplier locations, by applying a genetic algorithm that simultaneously minimizes distance and time; and  
providing a pickup route which comprises a pickup path that best simultaneously  
20 minimizes distance and time compared with all the other pickup paths searched.

11. The method as recited in claim 10, further comprising:  
accessing operational constraint information.

25

12. The method as recited in claim 11, wherein selecting supplier locations to fill the orders includes satisfying the operational constraint information.

13. The computer readable medium as recited in claim 10, wherein accessing the set  
30 of orders includes accessing current orders and buffered orders.

14. The computer readable medium as recited in claim 13, wherein accessing the set of orders further includes accessing orders for a particular delivery time period.

15. The computer readable medium as recited in claim 10, wherein selecting the set of  
5 supplier locations to visit to pick up products to fill the set of orders comprises:

computing a distance between each supplier location in the set of supplier  
locations; and

eliminating redundancies in the set of supplier locations by selecting a first  
supplier over a second supplier, when the first supplier's available  
10 products and second supplier's available products are the same, but the  
first supplier has more available products to fill the orders than the second  
supplier.

16. The computer readable medium as recited in claim 15, wherein the set of supplier  
15 locations includes a distribution center.

17. The computer readable medium as recited in claim 16, wherein searching for  
pickup paths visiting each supplier location in the set of supplier locations further  
comprises searching for pickup paths ending at the distribution center.

18. The computer readable medium as recited in claim 17, wherein the pickup route  
ends at the distribution center.

19. The computer readable medium as recited in claim 10, further comprising:  
25 determining a set of customer locations for each customer placing an order in the  
set of orders;

searching for delivery paths visiting each customer location in the set of customer  
locations, by applying a genetic algorithm that simultaneously minimizes  
distance and time; and

providing a delivery route, which comprises a path that best simultaneously  
minimizes distance and time compared with all the other delivery paths  
searched.

5     20.     The computer readable medium as recited in claim 19, further comprising:  
computing a distance between each customer location in the set of customer  
locations.

10     21.     The computer readable medium as recited in claim 20, wherein the set of  
customer locations includes a distribution center.

15     22.     The computer readable medium as recited in claim 21, wherein searching for  
delivery paths visiting each customer location in the set of customer locations further  
comprises searching for delivery paths starting at the distribution center.

20     23.     The computer readable medium as recited in claim 22, wherein the delivery route  
begins at the distribution center.

25     24.     A method of searching among locations for paths, comprising:  
randomly generating an initial population of chromosomes to be a current  
population, each chromosome holding a predetermined number of integers  
with one integer at each position in the chromosome, each integer  
representing one location from a set of locations;  
calculating a fitness for each chromosome in the current population, the fitness  
representing distance and time simultaneously;  
selecting one or more pairs of parent chromosomes from the current population  
based on their fitness to generate a new population;  
crossing over the pairs at a randomly chosen point, with crossover probability  $p_c$   
between about 0.6 and 0.9, to form offspring to generate the new  
30     population;

mutating the offspring at each position on their chromosomes, with mutation probability  $p_m$  between about 0.001 and 0.01, to modify the new population;

making the current population a previous population and replacing the current population with the new population;

forming new generations by repeating the calculating, selecting, crossing over, mutating, and making acts, until a previous best fitness in the previous population is the same as a current best fitness in the current population; and

providing a path represented by a chromosome having a best fitness in the current population.

25. The method as recited in 24, wherein the each population of chromosomes has  $2^k$  members, where the set of locations is of size  $k$ .

26. A computer readable medium having computer-executable instructions for performing the acts recited in claim 24.

27. The method as recited in 24, wherein crossing over the pairs at the randomly chosen point is carried out by implementing a greedy crossover operation.

28. The method as recited in claim 27, wherein the greedy crossover operation comprises generating offspring in the new population by:

placing all adjacencies shared by a first and a second parent in offspring;

alternating other adjacencies to be placed in offspring between the first and second parents; and

when an adjacency produces a conflict, placing a random location in the offspring instead so that a legal tour is maintained.

29. The method as recited in claim 27, wherein the greedy crossover operation comprises generating offspring by:

repeatedly placing a shortest parental adjacency to a location not yet visited in an  
offspring, if such shortest parental adjacency exists; and  
otherwise placing a random adjacency in the offspring that maintains a legal tour.

5 30. The method as recited in 24, wherein selecting the pairs of parent chromosomes  
from the current population based on their fitness is carried out by implementing a CHC  
selection operation.

31. The method as recited in claim 30, wherein the CHC selection operation  
10 comprises:  
placing the pairs of parent chromosomes in the new population.

32. The method as recited in claim 31, wherein the CHC selection operation further  
comprises:  
15 merging the new population with the current population based on fitness.

33. The method as recited in claim 31, wherein the CHC selection operation further  
comprises:  
upon determining premature convergence, retaining a number of the current  
20 population based on fitness and replacing the rest of the current population with  
randomly generated chromosomes.

34. A computer system for finding distribution chains to satisfy customer demand,  
comprising:  
25 a storage device;  
an output device; and  
a processor programmed for repeatedly performing a method, the method  
comprising:  
determining current orders;  
30 determining a set of locations to visit which comprises locations of  
suppliers with products available for the current orders;

determining a starting location in the set of locations;  
determining a distribution center proximate to customer locations, the  
customer locations being delivery locations for each customer who  
placed one of the current orders;  
5 applying a genetic algorithm to find a first route starting at the starting  
location, ending at the distribution center, and visiting each  
location in the set of locations, while minimizing distance and  
time;  
providing the first route on the output device; and  
10 storing any undelivered products in a buffer on the storage device to be  
included in the current orders and removing the orders that the first  
route will fill from the current orders.

35. The system as recited in claim 34, wherein the method further comprises:  
15 computing the distance between all locations, including each location in  
the set of locations, the starting location, and the distribution  
center.

36. The system as recited in claim 34, wherein the method further comprises:  
20 applying the genetic algorithm to find a second route from the distribution  
center to each customer location that minimizes distance and time;  
and  
providing the second route on the output device.

25 37. The system as recited in claim 36, wherein the method further comprises:  
computing the distance between each customer location and the  
distribution center.

30 38. The system as recited in claim 34, wherein the processor is a parallel processor.

39. A data signal having a data structure stored thereon, comprising:  
a first field containing locations; and  
a second field containing a request for a route through the locations in the first  
field.

5

40. A data signal having a data structure stored thereon, comprising:  
a field containing a route which comprises ordered locations to be visited.

41. The data signal as recited in claim 40 wherein the route is a delivery route.

10

42. The data signal as recited in claim 40 wherein the route is a pickup route.

43. A method of communication, comprising:  
receiving a plurality of locations and a request for a route through the locations;  
and  
sending, in response to the request, the route.

15